

Chromate-free Pre-painted Steel Sheet "J CraftTM" applied "GALFLEXTM" Specification

1. Introduction

In 1953, JFE Galvanizing & Coating Co., Ltd. (JFE G&C) began sales of pre-painted steel sheets for the first time in Japan. In 1993, the company began sales of a pre-painted hot-dip 55% aluminum-zinc alloy coated steel sheet, "JFE pre-painted GL" (hereinafter, "pre-painted GL"), and has accumulated a proven record of results over many years in the building materials field, centering on roof and exterior wall applications. From 2001, JFE G&C also began selling the "GALFLEXTM" specification as an option that dramatically improves the formability of pre-painted GL. The "GALFLEXTM" specification is used in applications that require high bending formability, focusing on Hokkaido (snowy and cold region in Japan), where quality requirements are particularly strict, and has won a high evaluation from customers. The coating layer of the hot-dip 55% aluminum-zinc alloy coated steel sheet (hereinafter, GL) used as the base steel sheet for pre-painted GL consists of approximately 55 wt% aluminum (Al), 43 wt% zinc (Zn) and 1.6 wt% silicon (Si), and displays a complex alloy structure of Al-rich phases and Zn-rich phases in a complicated reticulated structure. While this coating possesses excellent corrosion resistance, in some cases the corrosion resistance of bend portions is reduced by cracks in the coating layer caused by bending of the hard coating layer. The "GALFLEXTM" specification is a treatment process that achieves improved bending formability, and an accompanying improvement in the corrosion resistance of bend portions, by applying a proprietary technology to GL to soften the coating layer, making it possible to achieve excellent quality performance¹⁾. The name "GALFLEXTM" is a combination of "GALvanizing," meaning hot-dip Zn coating, and "FLEXible." This paper introduces the chromate-free pre-painted steel sheet "J CraftTM," focusing on the application of the "GALFLEXTM" specification to this new product.

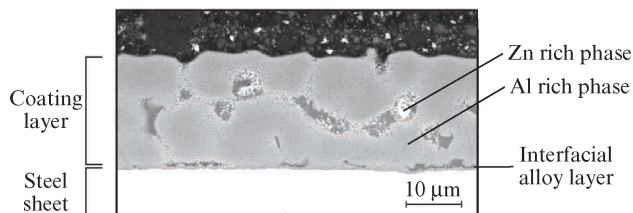


Fig. 1 Cross-sectional microstructure of coating layer of hot-dip 55% Al-Zn coated steel sheet

2. Features of "GALFLEXTM" Specification

2.1 Corrosion Protection Mechanism of GL

Figure 1 shows a cross-sectional view of the coating layer of GL. Although the coating layer consists of a complex microstructure of Al-rich phases and Zn-rich phases in a complicated reticulated structure, it is thought that this characteristic structure of the coating layer achieves high corrosion resistance by the following mechanism:

- ① Since the larger part (approximately 80% by volume) of the coating layer consists of the Al-rich phase, an Al-containing oxide film with high barrier performance is formed in the surface of the coating layer.
- ② The Zn-rich phase has a sacrificial corrosion protection effect and corrodes preferentially.
- ③ Due to the complicated reticulated structure, the corrosion paths along the Zn-rich phases are long, which delays the progress of corrosion.
- ④ In cases where the corrosion products formed by the Zn-rich phase are discharged out of the coating layer, the remaining spaces are filled with aluminum oxides originating from the Al-rich phase.

2.2 Aims of "GALFLEXTM" Specification

Although GL displays excellent corrosion resistance, as described above, the coating layer is hard and is prone to cracking under bending. In conventional pre-painted GL, when those cracks propagate in the painted layer, the corrosion resistance of bend portions is reduced by damage and loss of the coating layer and painted layer, which are barriers against corrosion.

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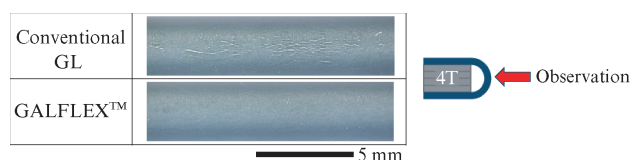


Fig. 2 Surface appearance of 4T-bent portion of pre-painted GL

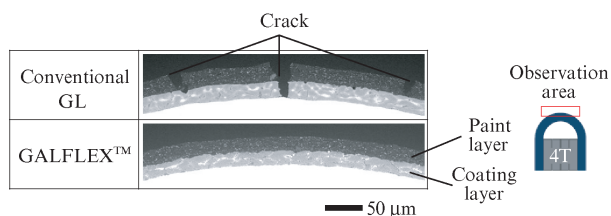


Fig. 3 Cross-sectional view of 4T-bent portion of pre-painted GL

Therefore, the “GALFLEX™” specification, in which bending formability is improved by softening the coating layer, is less likely to cause remarkable differences in corrosion resistance between flat areas and bend portions.

2.3 Effects of “GALFLEX™” Specification

2.3.1 Improvement of Bending Formability

Figure 2 shows the results of observations comparing the appearance of 4T-bent portions of pre-painted GL with and without the “GALFLEX™” specification. Although linear cracks can be seen in the bend portion of the conventional pre-painted GL without the “GALFLEX™” specification, no cracks can be observed with the “GALFLEX™” specification.

Figure 3 shows the results of a comparative observation of the cross sections of 4T-bent portions of pre-painted GL with and without the “GALFLEX™” specification. In the conventional pre-painted GL, cracks can be observed in both the coating layer and the painted layer, and among these three cracks, one crack located in the center is connected to the coating layer, indicating that the crack has propagated between the coating layer and painted layer. On the other hand, with the “GALFLEX™” specification, the occurrence of cracks was not observed in either the coating layer or the painted layer, confirming that the bending formability of pre-painted GL is improved by applying the “GALFLEX™” specification.

2.3.2 Improvement of Corrosion Resistance of Bend Portions

Figure 4 shows the results of a comparison of the corrosion resistance of the 4T-bent portions of pre-painted GL after 240 cycles of a combined cyclic cor-

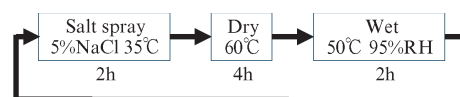


Fig. 4 Surface appearance of 4T-bent portion of pre-painted GL after 240 cycles of combined cyclic corrosion test

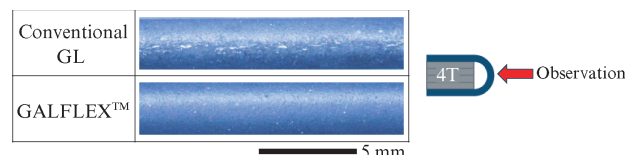


Fig. 5 Surface appearance of 4T-bent portion of pre-painted GL after 5-year outdoor exposure in industrial area (Chiba, exposed upward, face to south and tilted)

rosion test with and without the “GALFLEX™” specification. In the conventional pre-painted GL, the occurrence of white rust can be observed on the bend portion, but not any rust is observed with the “GALFLEX™” specification.

Figure 5 shows the results of a comparison of the corrosion resistance of the 4T-bent portions of the pre-painted GL with and without the “GALFLEX™” specification in a 5-year outdoor exposure test in an industrial area (Chiba, Japan). As in the combined cyclic corrosion test, the occurrence of white rust can also be observed at the bend portion of the conventional pre-painted GL in the outdoor exposure test, but rust cannot be observed with the “GALFLEX™” specification. Thus, these tests confirmed that the corrosion resistance of bend portions of pre-painted GL is dramatically improved by application of the “GALFLEX™” specification in both the accelerated corrosion test and the actual environment.

3. Application to Chromate-free Pre-painted Steel Sheet “J Craft™”

In anticipation of social needs for reduced environmental loads of recent years, JFE G&C promoted the development of a technology for realizing chromate-free treatment in place of the conventional chromate conversion treatment and began producing chromate-free pre-painted steel sheet products in 2006. From 2016, the company continued to sell these products as the chromate-free pre-painted steel sheet “J Craft™,” which also has enhanced weatherability of the polyester topcoat, and achieved cumulative sales of

1 million tons in 2025. Although “J Craft™” contains absolutely no chromate (hexavalent chromium), which is an environmentally hazardous substance, it conforms to all the performance requirements for pre-painted steel sheets, as follows:

- ① Corrosion protection by self-healing function.
- ② Suppression of corrosion reactions by formation of stable corrosion products.
- ③ Strengthening of barrier performance against corrosion factors.
- ④ Strengthening of adhesion with the base coated steel sheet.

Based on these results, “J Craft™” is an environment-friendly pre-painted steel sheet that demonstrates corrosion resistance equal or superior to conventional chromate-type pre-painted steel sheets²⁾. Although JFE G&C achieved chromate-free pre-painted GL with “J Craft™,” further addition of the “GALFLEX™” specification makes it possible to supply an “Only 1, No. 1” pre-painted GL with both outstanding environmental performance and excellent quality performance.

4. Conclusion

The “GALFLEX™” specification is an optional specification that demonstrates long-term durability in

practical use as a result of the improved bending formability of the pre-painted GL itself and the enhanced corrosion resistance of bend portions of formed products. In recent years, chromate-free products with low environmental loads have been demanded, while on the other hand, higher levels of durability have also been required in roof and exterior wall applications. To meet those requirements, in the future, JFE Galvanizing & Coating will continue to actively promote the application of the “GALFLEX™” specification to its chromate-free high corrosion resistance pre-painted steel sheet “J Craft™.”

References

- 1) Pre-painted 55% Aluminum-Zinc Alloy Coated Steel Sheet with High Formability “GALFLEX COLOR”. NKK GIHO. 2002, no. 176, p. 102–103
- 2) Chromate-free Pre-painted Galvanized Steel Sheet with Excellent Corrosion Resistance “J Craft”. JFE GIHO. 2018, no. 41, p. 95–96

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